Does ignoring predation mortality leading to an inability to achieve management goals in Alaska?

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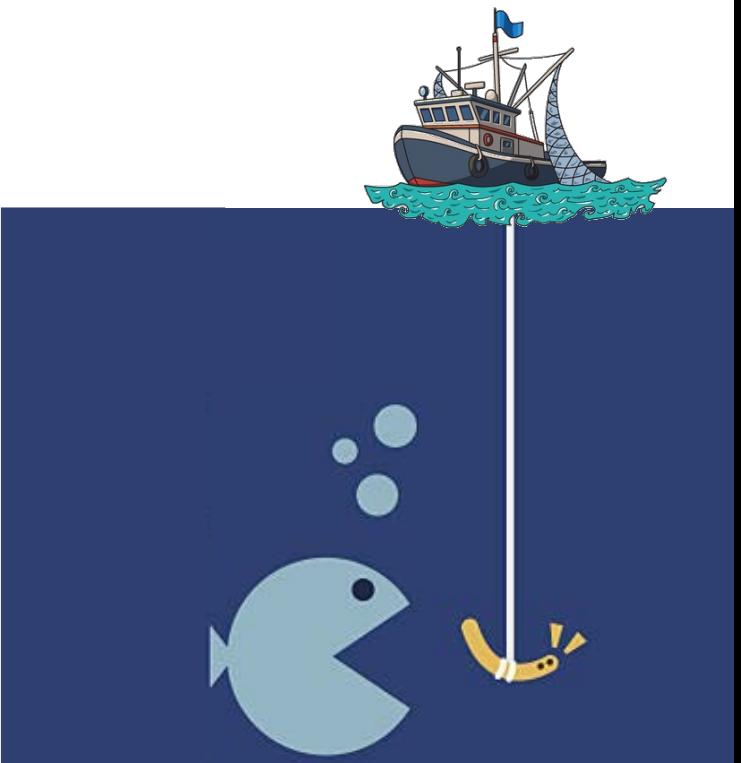
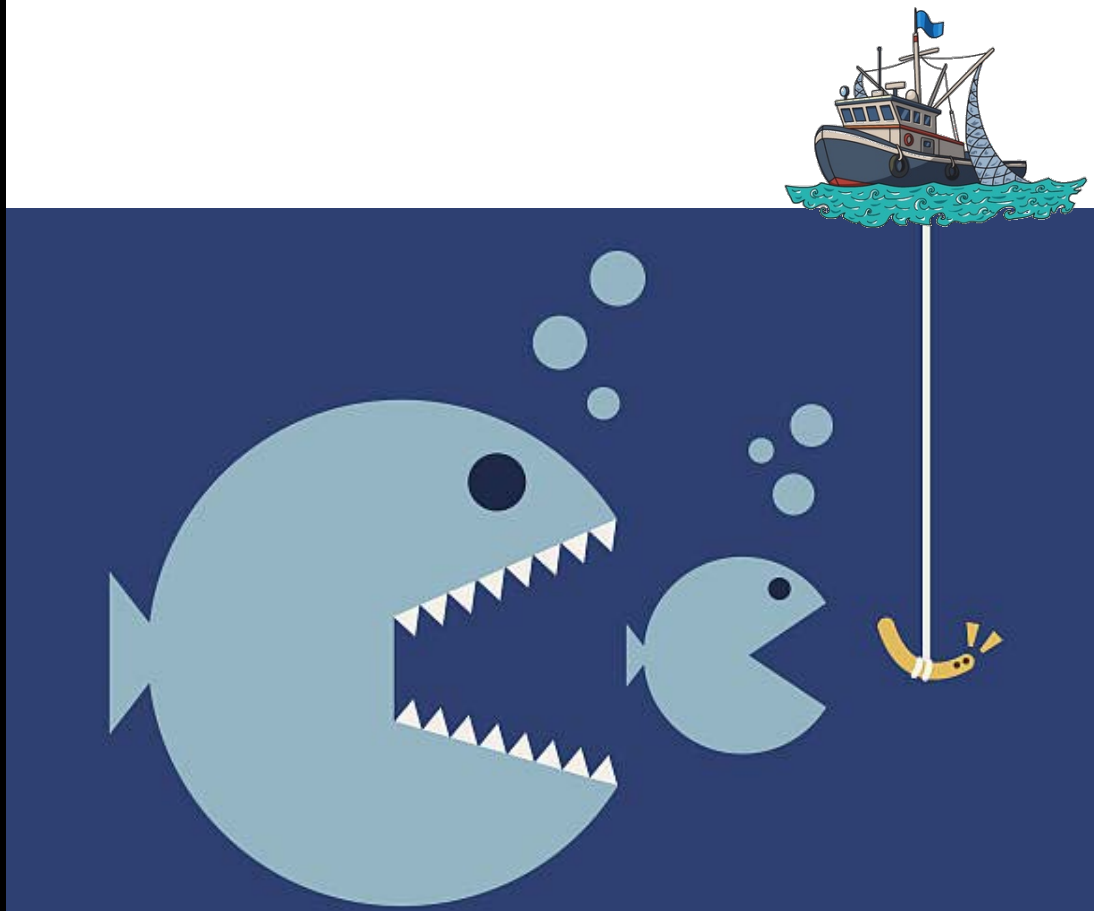
Sea Grant

Management models:



Single-species

Reality:



Multi-species

Consequences

Single-species models can lead to:

- Biased biological reference points
  - Maximum sustainable yield & proxies
  - Stock status
- Poor predictive performance (Trijoulet *et al.* 2020)
  - Over fit data
- Suboptimal decision making
  - Over- and under-harvest

Previous studies are limited

Two classes of studies:

- Projection studies
  - Evaluate predictive capacity
  - Consequences of management actions
- Simulation studies
  - **Multi-species** model simulates data
  - **Single-species** model fits to data
  - Bias in model outputs

Do not account for:

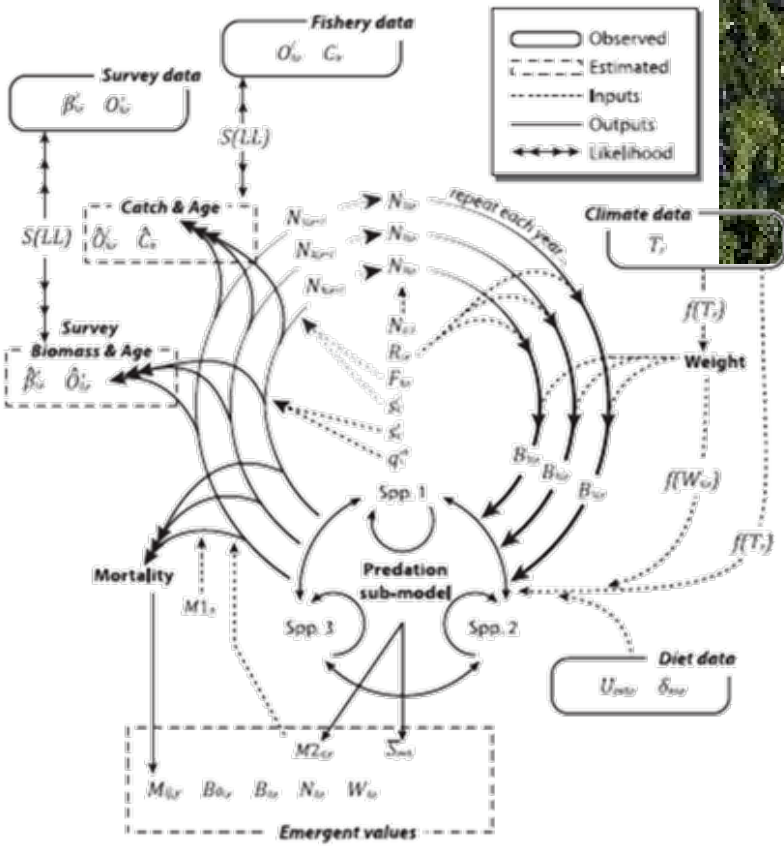
- Feedback control
  - Continued data collection
  - Refine management strategy
- Feedback between species

Objectives

- Does ignoring predation mortality leading to an inability to achieve management goals in Alaska?
  - Multi-species assessment model
  - Management strategy evaluation approach

SEATTLE

CEATTLE



CEATTLE=
Climate-Enhanced
Age-based Model
with Temperature-Based
Trophic Linkages and Energenics

Holsman et al. Deep Sea Research 2016

Age structured model

- Numbers

Total mortality

$$N_{sp,a+1,y+1} = N_{sp,a,y} e^{-Z_{sp,a,y}}$$

$$Z_{sp,age,yr} = M1_{sp,age} + M2_{sp,age,yr} + F_{sp,age,yr}$$

$$F_{sp,age,yr} = F_{0,sp} e^{\varepsilon_{sp,yr}} s^{f}_{sp,age}$$

sp = species

a = age

y = year

3 sources of Mortality

- Numbers

Total mortality

$$N_{sp,a+1,y+1} = N_{sp,a,y} e^{-Z_{sp,a,y}}$$

$$Z_{sp,a,y} = M1_{sp,a} + M2_{sp,a,y} + F_{sp,a,y}$$

Residual M

Predation M

Fishing M

sp = species

a = age

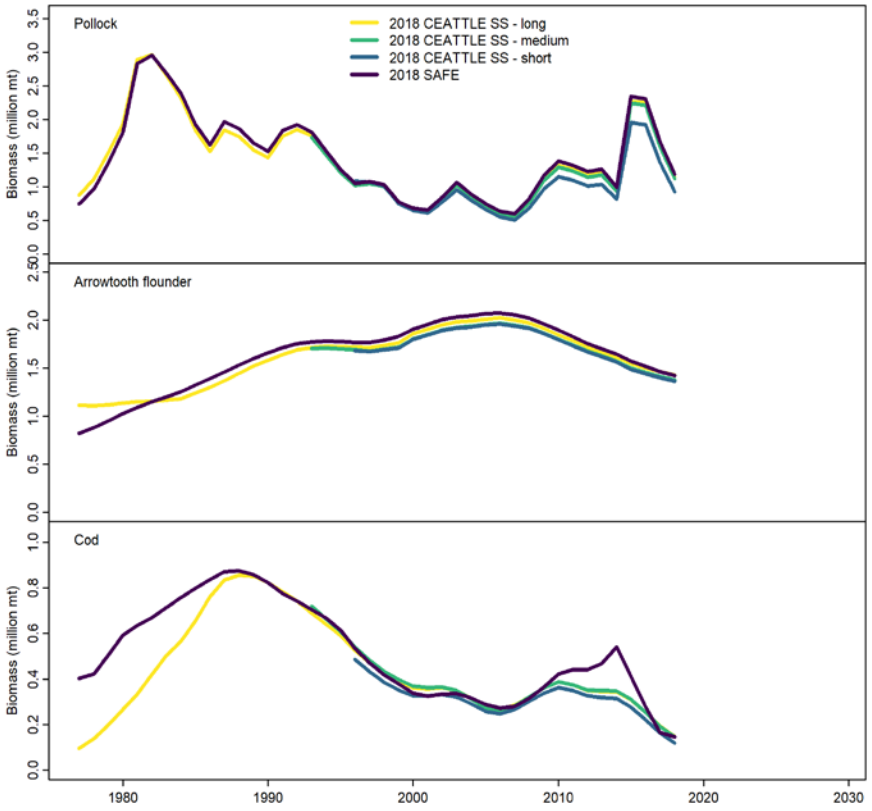
y = year

CEATTLE implementation

TMB based R package

Closely approximates stock assessments

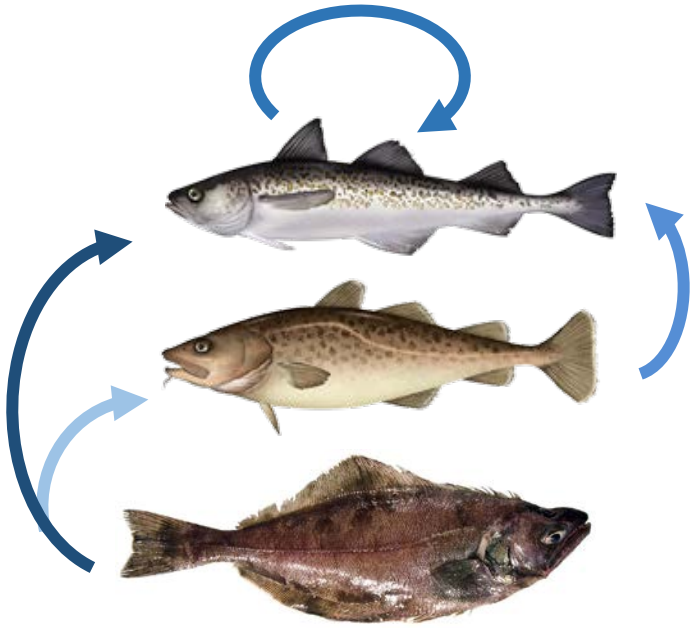
- Estimate time varying M
  - Input in assessments
- Explain population fluctuations
  - Predation vs environmental drivers
- Strategic management decisions
  - Trade-offs & future climate impacts
- Tactical management decisions
  - Multispecies harvest strategies
  - Multispecies biological reference points (Moffit et al 2016)
  - Ecological reference points (Chagaris et al., 2020)



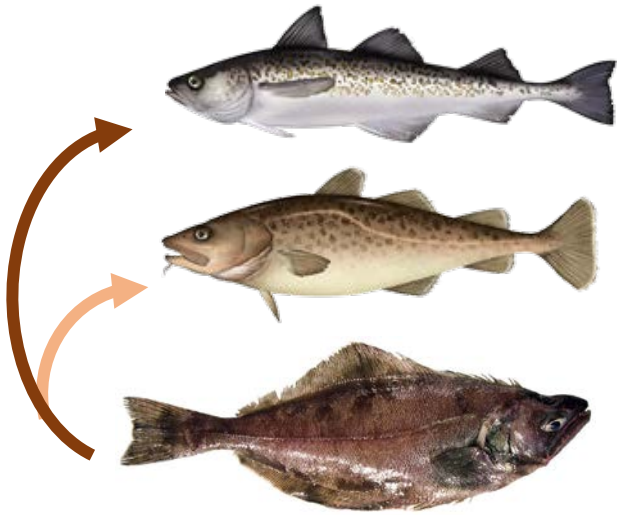
CEATTLE models

- Walleye Pollock
- Pacific Cod
- Arrowtooth Flounder

Eastern Bering Sea:



Gulf of Alaska:



MSE scenarios

Operating models:

1. Single-species fixed age-variant M (**Fix M**)
2. Single-species estimated age-invariant M (**Est M**)
3. Multi-species model

Systems:

1. Gulf of Alaska (GOA)
2. Eastern Bering Sea (EBS)

Recruitment trends:

1. Constant
2. All up or down
3. Only arrowtooth up or down

Run MSE from *2017/2018 to 2060*

Management strategies

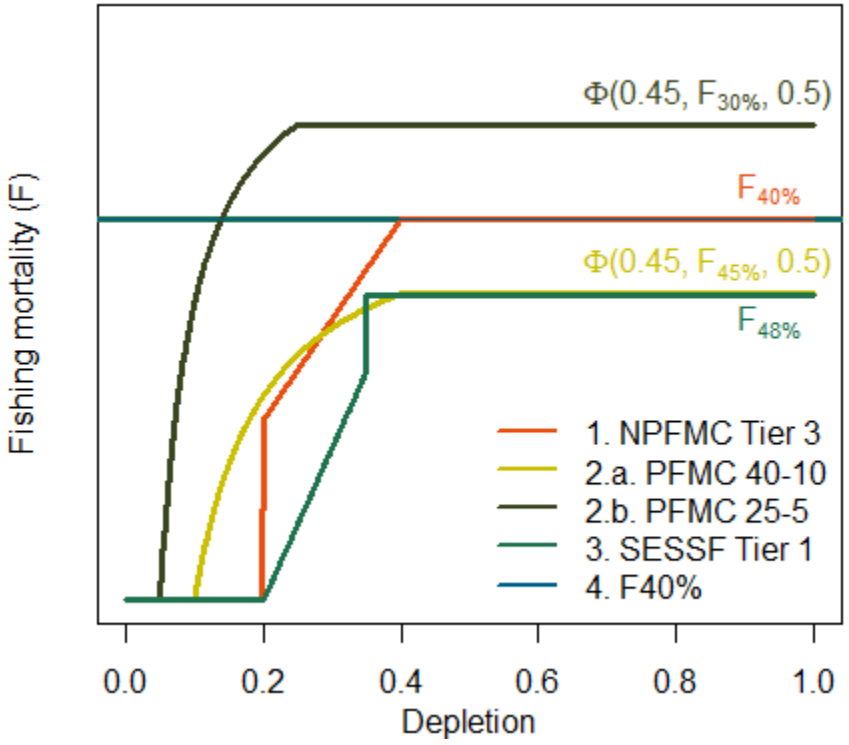
Single-species estimation models:

1. Fix M
2. Est M

Harvest control rules:

1. NPFMC Tier 3
2. PFMC Pstar
3. SESSF Tier 1
4. NEFMC F40%

Dynamic B0 biomass reference points



Performance metrics

Fishery goals:

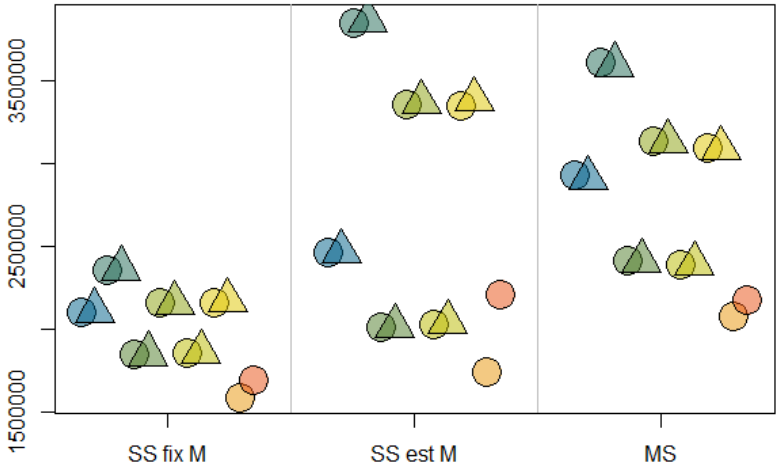
- Average catch
- Interannual catch variation
- Probability of the fishery being open

Conservation goals:

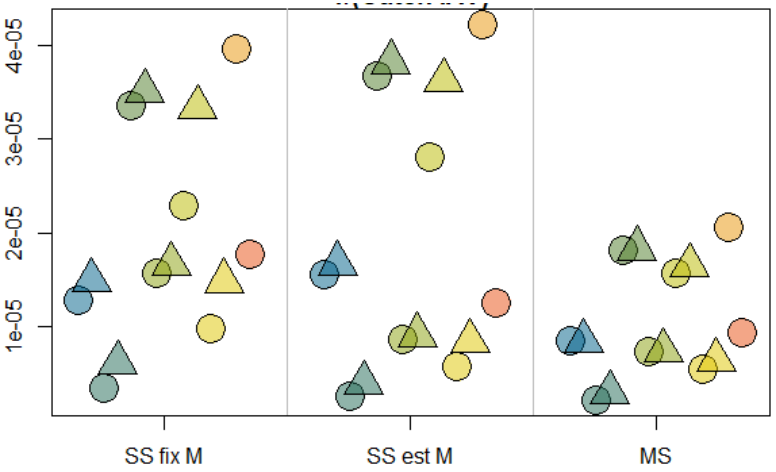
- Not overfished:
  - Perceived (EM)
  - True (OM)
- Not overfishing:
  - Perceived (EM)
  - True (OM)
- **Multi-species SB_{25}**

Fishery goals – Bering pollock

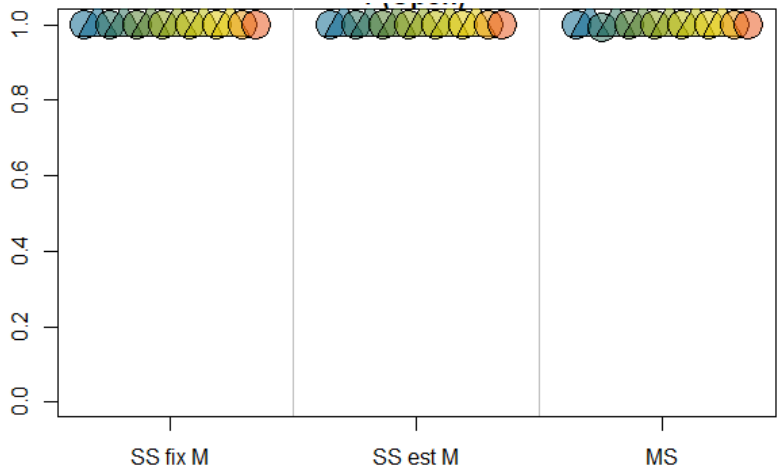
Average Catch



Interannual catch variability (reciprocal)



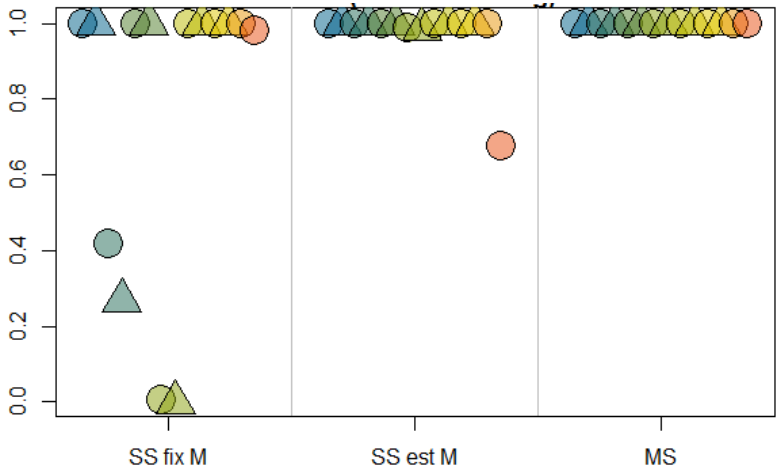
Probability of being open



- Fix M: NPFMC
- Est M: NPFMC
- Fix M: PFMC
- Est M: PFMC
- Fix M: SESSF
- Est M: SESSF
- Fix M: NEFMC
- Est M: NEFMC
- ▲ Dynamic BRP

Conservation goals – Bering pollock

Probability of not overfishing (OM)



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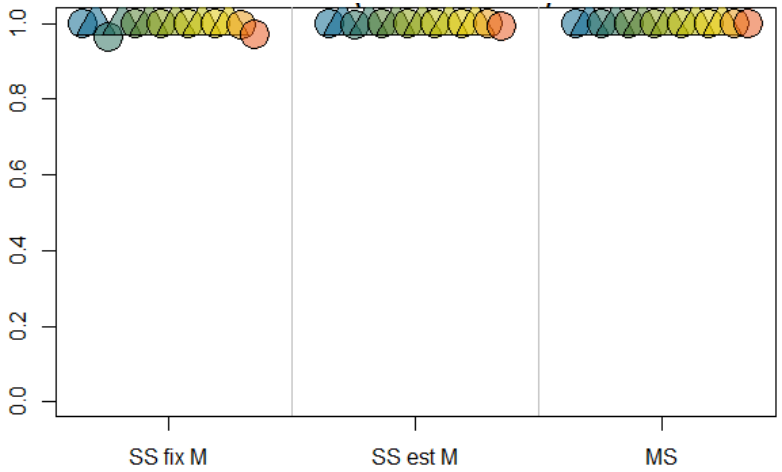
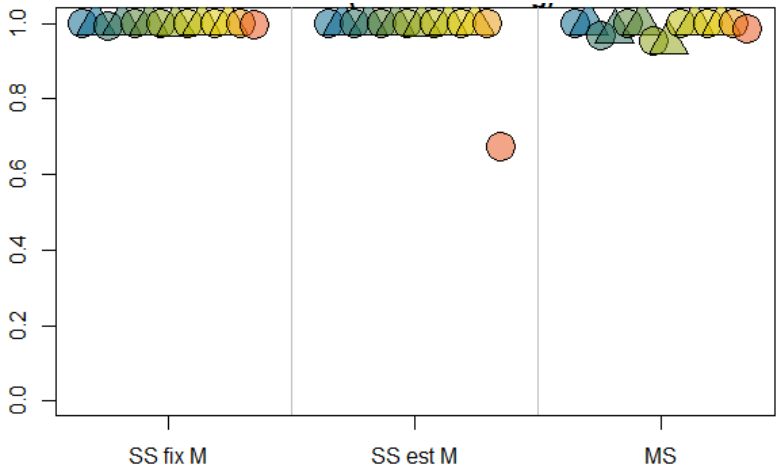


Perceived probability of not overfishing (EM)



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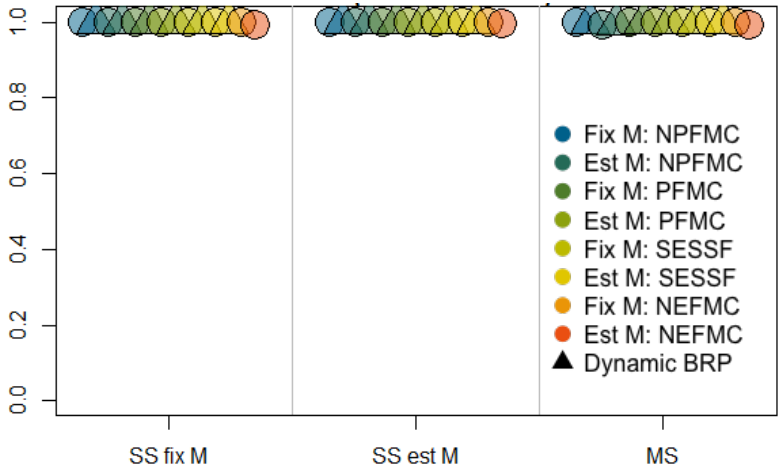
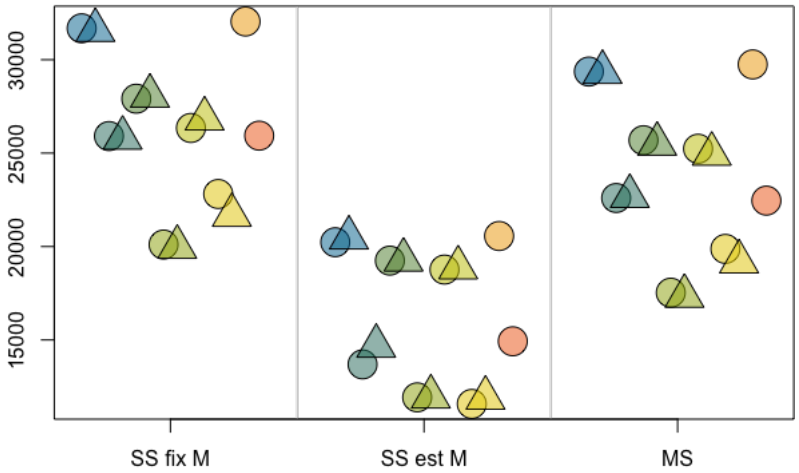


Fishery goals – Gulf cod

Average Catch



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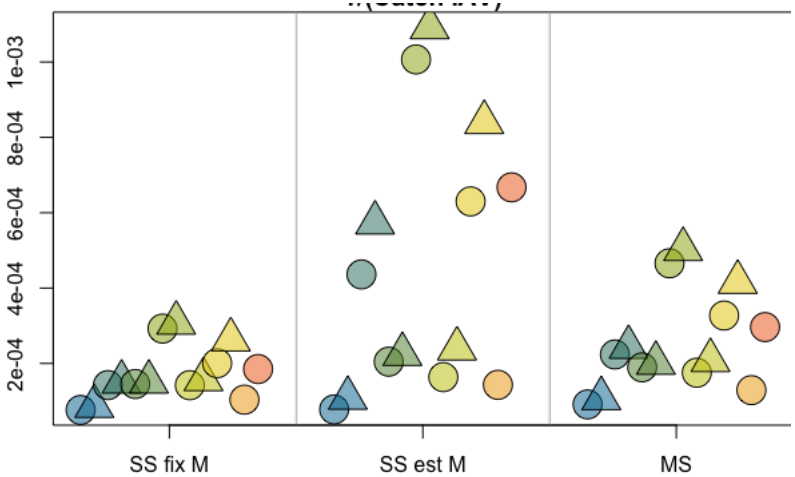
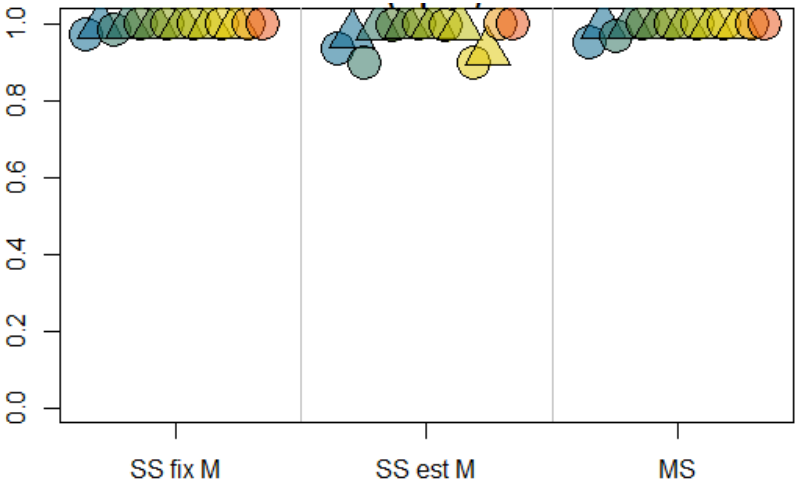


Probability of being open



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Conservation goals – Gulf cod

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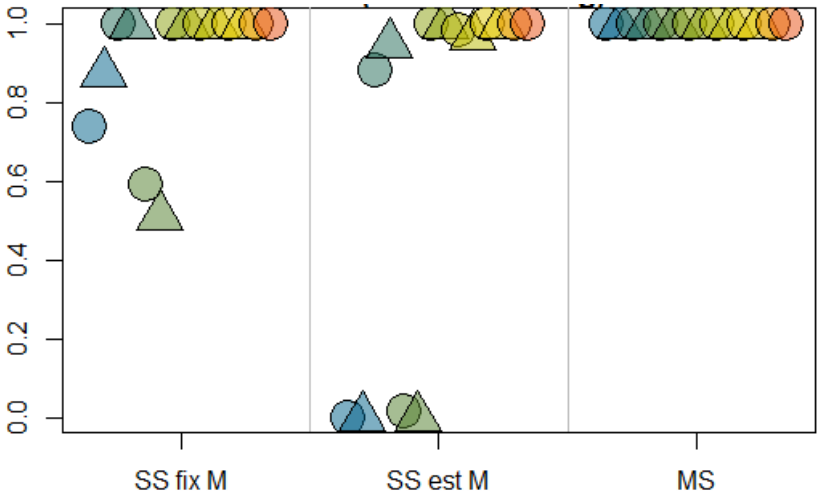

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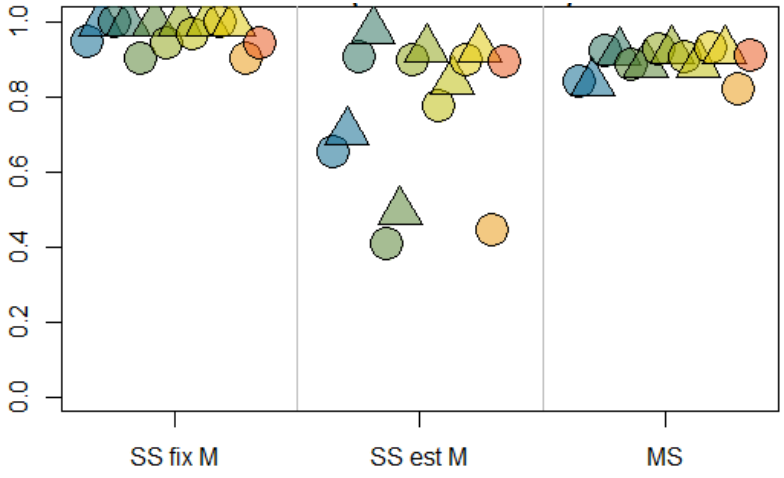

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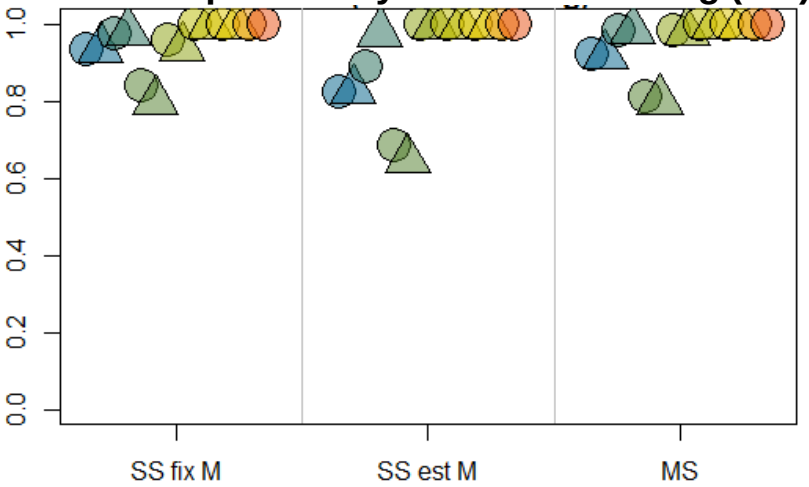

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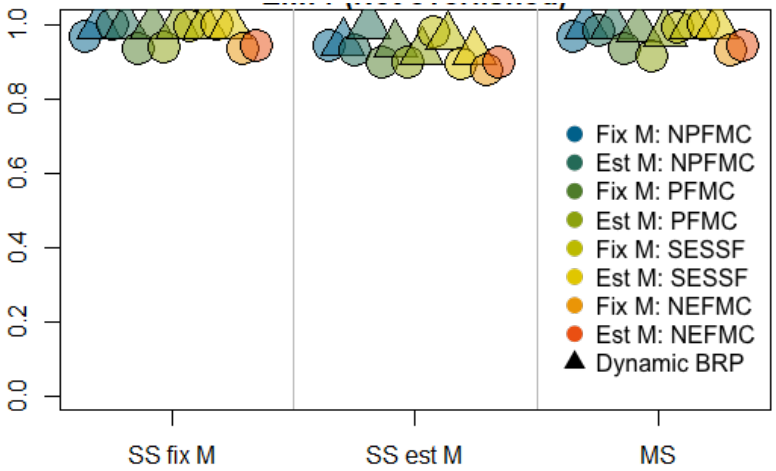

Summary

- Estimating M leads to better performance
  - Better approximate population scale
- Most management strategies achieve conservation objectives
  - Tiered harvest control rules outperform
  - Above multi-species SB25
  - Perceive to achieve objectives given predation
- Dynamic BRPs don’t improve performance
  - BUT ignore time-varying growth

Uncertainties and future research

- Easy to compare management strategies…
  - How to compare ***single- vs multi-species OMs***?

- Form of species interactions
  - Focused on top-down via predation
  - Sensitivity to functional form?
  - Bottom-up processes?

- More drastic recruitment trends? Other climate linkages?

- Underutilization of some stocks? Harvest caps?

- *Kirstin Holsman*
- *Ian J. Stewart*
- *André E. Punt*

Questions?

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https://github.com/grantdadams/Rceattle

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THANKS!

- *Kirstin Holsman*
- *Ian J. Stewart*
- *André E. Punt*